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The role of landscape amenities in regional development: a survey of migration, regional economic and hedonic pricing studies

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Abstract

Quality of life factors continue to gain importance in residential location decisions as well as location decisions of firms. One such factor is an attractive local landscape. The aim of this paper is to provide a survey of the empirical literature on the role of landscape amenities in local economic change. Following common amenity definitions, we define landscape amenities as landscape features that are location-specific, latent non-market input goods that directly enter residents' utility functions. Using this definition we identify thirty-nine relevant studies that use either migration or regional economic models or hedonic pricing techniques. One result from the analysis of migration and regional economic studies is that intra-country migrants were attracted by amenities about as frequently as by a low tax burden. Effects of amenities on employment and income are less well established. However, many of these studies used rather limited amenity variables. The results from hedonic studies show that a wide variety of local amenity attributes are partly capitalized in housing prices and that studies on a larger geographic scale are more likely to identify a significant a role of amenities. Newly available land cover datasets and spatial analysis tools have the potential to overcome important data limitations of many earlier studies. Future research may thus contribute to a better understanding of the role of landscape amenities in economic change and to a better coordination of regional and environmental policies.

JEL classification: Q26, Q51, R11, R23

Keywords: landscape amenities, migration, local development, hedonic models, environmental valuation, regional economic modeling, land use

1 Introduction

Traditional regional economic and migration studies largely ignored the possible effects of location-specific non-market goods on demographic and economic change. Starting in the 1970s, however, two fundamental changes in U.S. internal migration patterns occurred (Greenwood, 1985): First, net-migration flows turned from the Northeast to the amenity-rich southern and western states; and second, the population growth in non-metropolitan regions started to exceed that of metropolitan areas.[1] Searching for explanations of these developments, an increased demand for location-specific amenities – resulting from scarcity of natural amenities caused by urbanization as well as generally rising real incomes – was identified as one of the possible causes (Greenwood, 1985; Deller et al., 2001). Since that time, economists and regional scientists have shown an increasing interest in the role of environmental amenities in local and regional development. New modeling approaches such as regional growth models in a simultaneous equations framework allowed them to explore the links between amenities, population, and economic development.

It seems reasonable to assume that the amenities that affect property prices are partly the same as those promoting amenity-based development processes. With the development of the hedonic pricing technique, researchers obtained a powerful new tool to explore the valuation of local amenity attributes at the micro level. Although traditionally a separate literature, hedonic pricing studies can thus potentially contribute to a better understanding of amenity-driven processes measured at the community and county levels. While early contributions in these fields used relatively limited amenity measures that included mainly climate amenity attributes or disamenities such as air and water pollution, it was in the 1990s when empirical researchers began to explore the role of a wider range of specific measures of natural and environmental amenities. Around that time, periurban amenities also gained increased interest in public policy as a factor that contributes to the quality of life and may be relevant to firm location decisions (e.g. Gottlieb, 1995; Cavailhès et al., 2004). Governments started to shift agricultural support policies from producer support towards compensation for the provision of environmental amenities, while several researchers also advocated the management of natural amenities as a development tool for rural regions (e.g. Deller et al., 2001; Green, 2001; Feinerman and Komen, 2003; Fuller et al., 2005; Marcouiller and Clendenning, 2005).

[1] This pattern changed in the 1980s when there was a revival of metropolitan net migration. However, in the 1990s net migration flows were in favor of rural areas again (see Fuguitt and Beale, 1996).

The goal of this paper is to provide a survey of the rapidly growing literature on the role of landscape amenities in regional and local demographic and economic change. We define landscape amenities as location-specific aesthetic or recreational values of landscapes, contained in open space, forest, national parks, wilderness areas and similar landscape attributes. We seek answers to two main questions. (1) Do landscape amenities promote population growth and economic development, and what is the importance of amenities relative to economic factors? We analyze the available empirical literature using migration models and models of regional growth (14 studies) to provide an overview of evidence on the generally not well-understood links between landscape amenities, population growth, and economic performance. (2) Which landscape amenity attributes are valued? To answer the second question, we use a meta-analysis regression to analyze evidence from the hedonic pricing literature (25 studies) on landscape amenities valuation.

We find that migrants were attracted by amenities roughly as frequently as by a low tax burden, while the effects of amenities on employment and income are less well established. A meta-analysis of the evidence from hedonic studies shows that a variety of amenity attributes are partly capitalized in housing prices and that that significant amenity effects are more frequent when hedonic studies were conducted at regional rather than local scale.

The remainder of this paper is composed of five sections. In the next section, we review the migration, regional economic, and hedonic pricing model approaches used in the empirical studies and discuss their specific potential to advance our understanding of the role of amenities in the development process. Section 3 contains the definitions and selection criteria we use to analyze the existing empirical literature. In section 4 we then review the evidence from models linking landscape amenities to demographic and economic development, while section 5 analyzes the evidence from hedonic pricing studies. A final section presents conclusions.

2 Modeling amenity effects in migration, regional economic, and hedonic pricing models

2.1 Amenities and migration: equilibrium and disequilibrium view

Traditional micro theory views migration as a reaction to spatial *disequilibria*. People migrate in order to reach higher utility. They react to regional differences in economic opportunities, for example by migrating from low- to high-wage regions. Hence, in the disequilibrium view,

migration is mainly a function of labor market variables. Since regional differentials are assumed to be associated with spatial disequilibrium, such differences in wages, rents or employment are sometimes referred to as *noncompensating differentials* (Hunt, 1993). Noncompensating differentials thus encourage migration as an equilibrating mechanism. An extensive body of literature on disequilibrium models has been built up since the early 20th century. Surveys are provided by Greenwood (1975, 1985) and Hunt (1993). Amenities play virtually no role in traditional disequilibrium models.

A classical example of the disequilibrium view of migration theory is Sjaastad's (1962) human capital approach to migration theory, in which he states (p. 80): "[…] little has been done to determine the influence of migration as an equilibrating mechanism in a changing economy. The movements of migrants clearly are in the appropriate directions, but we do not know whether the numbers are sufficient to be efficient in correcting income disparities as they emerge. There is a strong presumption that they are not." Relativizing this disequilibrium rationale, Sjaastad already mentions amenities and disamenities such as climate, smog and congestion as potential "non-money returns to migration" (Sjaastad, 1962, p. 86).

In the late 1970s, an alternative model approach evolved, which has its roots in urban economics. In contrast to disequilibrium models, the *equilibrium* models allow for spatial differences in economic opportunities even in a spatial equilibrium. One of the first advocates of the equilibrium view was Graves, who explains the underlying rationale as follows (Graves, 1980, p. 227): "In this view of migration, market rents and wages are expected to adjust so as to leave utility constant over space. Hence, within a city rent differentials will emerge to remove any advantages associated with access to the center, parks and the like, while across cities wages will be lower in desirable areas by an amount equivalent in utility to the amenities obtained by locating there. Migration, viewed in this way, takes place as a result of changes in demand for location-fixed amenities". Spatial differences in wages or economic opportunities are viewed as compensation for different amenity endowments. Hence, such differences are commonly referred to as *compensating differentials,* since they are of purely compensating nature and do not induce migration (Greenwood et al., 1991). The crucial explanatory variables in equilibrium migration models are amenity variables and factors that may lead to changes in demand and supply of amenities. These factors include growing real incomes (see Graves and Linneman, 1979) combined with the generally assumed high income elasticity of demand for amenities (e.g. Marcouiller and Clendenning, 2005), as well as changing relative prices, which lead the system to a new equilibrium. Such adjustment processes are believed to occur relatively quickly, unlike those associated with the disequilibrium

approach, where the tendency towards equilibrium is assumed weaker and the migration process and factor markets are viewed as less efficient (Hunt, 1993). Knapp and Graves (1989) provide an extensive review of equilibrium models.

Whether equilibrium or disequilibrium models are more appropriate for modeling migration is at least partly an empirical issue. Hunt (1993) analyzes the empirical literature related to this question. He finds evidence in favor of both approaches. Both the amenity consumption and the job search motive seem to determine migration, while the relative importance of the two motives remains unclear. However, it is important to note that most early studies and some of the newer studies use relatively narrow amenity measures containing only few amenity types such as climate or water variables, or disamenities such as air pollution and crime (e.g. Graves, 1976; Mueser and Graves, 1995; Clark and Murphy, 1996). Since the econometric evidence supports the idea that amenities are capitalized in wages and rents and that migration is partly amenity driven, Hunt (1993) concludes that pure disequilibrium models are misspecified. On the other hand, in most studies, economic opportunity variables are found to be significant migration determinants, which implies spatial disequilibrium and inefficient markets.

2.2 Regional economic models of amenity effects on population, employment and income

Natural amenities receive a growing attention not only in migration economics but also in the literature on regional growth and change. This literature explores the impact of location-specific amenities both on population and on the local or regional economy as a whole. To model the impact of amenity and other exogenous variables on multiple dependent variables such as population, employment and income change, as well as interactions of those dependent variables, system-of-equations models are often employed. Models of this type have traditionally been used to explore empirically whether people follow jobs or jobs follow people. One such example is the classic study by Steinnes and Fisher (1974), which explained intraurban location of residents and employment in a two-equation microeconomic model.

Carlino and Mills (1987) apply Steinnes and Fisher's intraurban system-of-equations model to an interregional context in order to explore the determinants of county growth in the USA. This model has the following underlying assumptions on household and firm behavior[2]: Households and producers are geographically mobile and choose their location in order to maximize their utility or profits, respectively. Consumer utility is derived from goods and

[2] Steinnes and Fisher (1974) provide a detailed microeconomic derivation of the system of equations and its underlying assumptions.

services as well as from non-market, location-specific amenities. Firms maximize their profits by optimizing production costs and choice of a regional market. The result is an adjustment process in which "firms enter and leave regions until profits are equalized among regions at competitive levels, and households migrate until utility levels are equalized at alternative locations" (Carlino and Mills, 1987, p. 40).

The framework by Carlino and Mills was advanced later, and several authors focussed on the role of amenities in the development process. Early contributions to this line of research used regional dummies as proxies for location-specific amenities (e.g. Carlino and Mills, 1987) or weather variables and costal dummies (e.g. Clark and Murphy, 1996), and it was not until the 1990s that landscape amenities (as defined in section 3.1) were considered in empirical research. Such extension may be essential for the empirical validity of the Carlino-Mills approach, as stressed by Graves and Mueser (1993, p. 78): The Carlino-Mills model "assumes that measured variables fully determine the ultimate equilibrium population. If there are any unmeasured stable differences between locations […], this imparts a systematic bias that will reduce the apparent speed of movement toward equilibrium." Graves and Mueser explicitly note natural amenities and land rents as essential and often wrongly omitted variables.

In response to Graves and Mueser's critique, several authors started using modified versions of the Carlino and Mills model in recent years. Among the most influential work in this field of research is the study by Deller et al. (2001). The general form of their model is (Deller et al., p. 355) [3]

$$(1) \qquad P^* = f\left(E^*, I^* \mid \Omega^P\right)$$

$$(2) \qquad E^* = g\left(P^*, I^* \mid \Omega^E\right)$$

$$(3) \qquad I^* = h\left(P^*, E^* \mid \Omega^I\right)$$

where the P^*, E^*, and I^* denote the equilibrium levels of population, employment, and per capita income. Ω^P, Ω^E, and Ω^I are a set of variables describing initial conditions and exogenous factors such as local economic conditions and several amenity measures. Deller et al. (2001) proposed a linear specification of this model, and they rearranged the terms in order to

[3] In order to improve the understanding of the link from amenities to economic well-being, Deller et al. (2001) not only used sophisticated amenity measures but also added a third equation for income to Carlino and Mills' (1987) basic model. Additionally, this specification allows testing for income as a migration determinant.

specify the changes ΔP, ΔE, and ΔI rather than equilibrium values on the left-hand side of the equations[4] (p. 356):

$$(4) \qquad \Delta P = \alpha_{0P} + \beta_{1P} P_{t-1} + \beta_{2P} E_{t-1} + \beta_{3P} I_{t-1} + \gamma_{1P} \Delta E + \gamma_{2P} \Delta I + \sum \delta_{IP} \Omega^P$$

$$(5) \qquad \Delta E = \alpha_{0E} + \beta_{1E} P_{t-1} + \beta_{2E} E_{t-1} + \beta_{3E} I_{t-1} + \gamma_{1E} \Delta P + \gamma_{2E} \Delta I + \sum \delta_{IE} \Omega^E$$

$$(6) \qquad \Delta I = \alpha_{0I} + \beta_{1I} P_{t-1} + \beta_{2I} E_{t-1} + \beta_{3I} I_{t-1} + \gamma_{1I} \Delta E + \gamma_{2I} \Delta P + \sum \delta_{II} \Omega^I$$

The endogenous variables in this system depend on the initial conditions $P_{t\text{-}1}$, $E_{t\text{-}1}$, and $I_{t\text{-}1}$, as well as on the changes of the two other dependent variables and on the vectors of exogenous factors Ω^P, Ω^E, and Ω^I.

Following Carlino and Mills (1987) and Deller et al. (2001) several papers employ the system-of-equations framework to the analysis of landscape amenity effects. Depending on whether the focus is solely on the direct amenity effects or also on the interplay of the endogenous variables, these studies estimate reduced forms of the model (e.g. Deller et al., 2001) or use simultaneous equations estimation methods such as two-stage least squares (e.g. Duffy-Deno, 1998) or the three-stage least squares technique (e.g. Lewis et al., 2003) to estimate the structural coefficients.

We analyze the empirical literature on such regional economic models containing landscape amenity variables in section 4.

2.3 Amenities, rents, and wages: hedonic pricing models

Alongside the migration and regional economic models introduced above, there is a further model type which contributes to the understanding of the role of amenities in economic change: the hedonic pricing (HP) models. HP models allow to compare the values of different amenity types by exploring implicit preferences from property price data. The HP approach, whose theoretical framework was established by Rosen (1974), derives price equations from property sales data by regression and therewith allows to valuate different exogenous attributes of the property itself and its vicinity. Underlying this method is the equilibrium view introduced in section 2.1. Given mobile workers and mobile firms in a spatial equilibrium, spatial differences in land prices and wages compensate for differentials in the amenity endowment (Hunt, 1993). Freeman (1979) provides a survey of HP theory and early HP studies. The hedonic price function describes the property price as a function of three categories of inde-

[4] Hunt (2006) uses the term *flow specification* for this model type as opposed to the *levels specification* (e.g. Carlino and Mills, 1987), which relates endogenous variables measured in levels instead of changes.

pendent variables: structural, neighbourhood, and environmental property attributes (Freeman, 1979). One subcategory of environmental variables is amenities. The HP method therefore allows estimating the impact of different amenity measures on property prices. The first step in an HP study is to calculate the implicit price of the attributes of interest by hedonic regression. Using this information and data for observed quantities and income, inverse demand and marginal willingness to pay functions can be estimated in a second step (Freeman, 1979). In most landscape amenity HP studies, this second step is omitted.[5]

A central feature of the HP method is its ability to reveal preferences for different amenity types. The high spatial resolution and the possibilities offered by remote sensing and Geographical Information Systems (GIS) allow to create very distinct amenity measures. Moreover, the effects of accessibility, distance or visibility of amenity features can be captured. This high spatial resolution and distinctness usually comes at the cost of small spatial coverage meaning that HP studies often cover only one neighbourhood, one community, or one county.

The interpretation of hedonic property value studies has some noticeable limitations. As shown by Roback (1982, 1988) and subsequent empirical work, amenities may be capitalized not solely in property prices but also in wages. Consequently, single-market studies may underestimate amenity values (Graves and Knapp, 1985)[6]. Another issue is that the assumptions underlying the hedonic technique, in particular the assumption of equilibrium in the housing market, are criticized. In his review article on HP theory and its early applications, Freeman (1979) concludes "[…] these criticisms can be raised against virtually any empirical work in economics" (p. 155) and that "it must be acknowledged that there are many respects […] in which the assumptions about the nature of the housing markets and preferences are oversimplifications. But the question is not whether the model is perfect, but rather does it provide a useable vehicle for increasing our knowledge? The results from over a dozen studies indicate the model has substantial explanatory power with respect to housing prices" (p. 171). Furthermore, there are some critical econometric issues. Estimation results are sensitive to the choice of the functional form, which cannot be purely theoretically determined (Rosen, 1974). Halvorsen and Pollakowski (1981) propose flexible functional forms that are determined by the data, while Cropper et al. (1988) conclude that the linear Box-Cox specification

[5] Exceptions are e.g. Garrod and Willis (1992) and Mahan et al. (2000).

[6] Nevertheless, all the HP studies containing landscape amenities analyzed in section 5 of this paper are single-market hedonic property value studies. To our knowledge there are virtually no multi-market HP studies containing landscape amenity variables such as those defined in section 3. An exception is Riddel (2001) who estimated the effect of an open space purchase program on property prices and wages in a dynamic multi-market model. An example of an early multi-market HP study is Hoehn et al. (1987). They estimated an interregional model of wages and housing prices using non-landscape natural amenities data such as climate and pollution variables.

is most appropriate. A more recent issue concerns the consequences of spatial autocorrelation resulting from spatially correlated omitted variables. Its neglect in HP or other cross-sectional data leads to inefficient estimates and biased standard errors (Leggett and Bockstael, 2000) and therefore demands alternative specifications, as proposed in Anselin (1988). Can (1992) and Dubin (1992) discuss spatial autocorrelation issues specifically in HP models.

We provide a meta-analysis of hedonic property value studies containing landscape amenity variables in section 5.

3 Definitions and selection criteria

3.1 Definition of amenities

In sections 4 and 5 of this article, we analyze the empirical literature on the role of natural landscape amenities in local economic and demographic change in developed countries. Following common amenity definitions (e.g. Gottlieb, 1995; Deller et al., 2001; Green, 2001; Marcouiller and Clendenning, 2005) we define natural landscape amenities as landscape features that are location-specific, latent non-market input goods of an economy that directly enter a resident's utility function. Landscape amenity attributes are demanded for their recreational and aesthetic utilities rather than as raw materials used in the production process. Examples of such attributes are agricultural land, forests, wildlife habitats, natural preserve areas, wetlands and open space. Other commonly analyzed amenity attributes, such as air quality, watercourses, and "non-natural" green space such as city parks, are not the subject of our analysis. A further prerequisite is that natural landscape amenities must be identifiable and not part of a broader composite index that also contains, for example, non-environmental amenities.

3.2 Model types and sources

All articles we analyzed use revealed preference models relating landscape amenities to economic change. Stated preference methods such as contingent valuation studies are thus not part of our survey (e.g. Von Reichert and Rudzitis, 1992; Johnson and Rasker, 1995; Earnhart, 2006). The literature considered in this survey consists of three different model types. *Migration models* relate amenities and other variables to net migration (e.g. Clark and Hunter, 1992) or gross migration (e.g. Porell, 1982). Therefore, they are appropriate to answer questions related to the determinants of migration. *Regional economic models* aim to identify the

effects of amenities on change in population, employment and income, and to capture interactions between these variables. They are usually designed as simultaneous equations models. Migration and regional economic studies that consider natural landscape amenities are reviewed in section 4 of this paper. The third model type considered are *hedonic pricing (HP)* studies (see also section 2.3), which we analyze in a meta-analysis model framework in section 5. HP models derive price equations from property sales data and are commonly used to price environmental goods such as natural landscape amenities.

The articles we chose for our survey in the sections 4 and 5 were all published in peer-reviewed journals between 1970 and 2006. We found most articles by searching the databases "Web of Science" and "Econlit".[7] We used several combinations of the following keywords: (1) resource keywords: landscape, open space, amenities, natural, federal land, preservation; (2) model keywords: carlino, hedonic; (3) other keywords: population, employment, income, growth, wage. Using these queries we found 307 articles of which 39 (14 regional economic and migration studies and 25 hedonic pricing studies) fulfilled the above criteria.

4 Empirical evidence from regional economic and migration models

The regional economic and migration studies analyzed in this section are heterogeneous in several dimensions: by model type, amenity variables, dependent variables, geographical coverage and the estimation method employed. Given the small number of available studies, this heterogeneity did not permit a quantitative analysis of the reported evidence. Instead, we analyzed the evidence in a semi-quantitative review of reported effects. Specifically, we examine the frequencies of significant reported amenity impacts on population/migration, employment and income variables, and we compare these with the impacts of fiscal and economic opportunity variables.

4.1 Study sample and amenity types

Based on the criteria defined in section 3, we found 14 articles with 36 reported estimates of amenity impacts on dependent variables of the three categories "demography", "employment" and "income" (see Appendix A). The articles were published between 1982 and 2005 in nine academic journals mainly in the fields of regional, agricultural, and urban economics. All study areas were located within the United States. Most studies used county-level data. Some researchers chose other spatial resolutions, namely municipalities (Gottlieb, 1995), Bureau of

[7] Additional literature was searched by consulting the references of relevant articles.

Economic Analysis economic areas (Greenwood and Hunt, 1989) and "Standard Metropolitan Statistical Area" (SMSA) census units (Porell, 1982). The majority of the studies employ regional economic system of equations models. Two studies (Porell, 1982; Clark and Hunter, 1992) employ single-equation migration models with migration flows as the sole dependent variable. Six articles (see Appendix A) control for spatial autocorrelation by constructing a spatial weight matrix and testing the null hypothesis of spatial independence using a spatial autocorrelation statistic such as Moran's *I* (see e.g. Anselin, 1988). None of these studies dates from before 1995.

The amenity measures in our sample are usually defined as proportions of a certain land-use category relative to the total land surface. Many studies use the proportion of land governed by state or federal agencies, such as the National Park Service (NPS) or the United States Forest Service (USFS) as their amenity variable (e.g. Duffy-Deno, 1997a, 1997b, 1998). Others use land-use categories such as wilderness land, conservation land, or forest land (e.g. Booth, 1999; Nzaku and Bukenya, 2005). Such measures are not uniformly defined and reported categories may overlap among studies. A third approach for the construction of amenity measures are amenity indices constructed by means of the principal component method (Porell, 1982; Kim et al., 2005; Deller et al., 2001). A useful distinction of land amenities is not possible in these studies. The migration and regional economic studies that we analyzed thus do not allow us to answer questions regarding the effects of specific amenity types.

4.2 Reported amenity effects on demography, employment and income

An overview of the landscape amenity effects on different demographic and economic variables is provided in Table 1. The dependent variables of the migration and regional economic studies analyzed here can be summarized in three categories: population and migration (occurring in 13 studies), employment (occurring in 11 studies) and income (occurring in 5 studies). Overall, of 36 estimated amenity effects[8] on these dependent variables, 14 (38.9%) were positive and significant. Three negative effects were found, and the remaining 19 coefficient estimates were non-significant. The highest proportion of positive and significant coefficient estimates was found for effects on variables of the category "population and migration" where 7 out of 15 coefficients were significant and positive. The proportion for the income equations was almost as high as this. However, there were only seven reported income effects estimated

[8] Since some of the amenity coefficients estimated stem from different equations of the same simultaneous equations model, the 36 coefficients are not completely independent.

in five different studies. All three significant estimates were obtained for specific types of income (wages, dividends and transfers) rather than for total per capita income. Moreover, all significant estimates stem from one single study (Booth, 1999). Therefore, it is not possible to make any general statements regarding the impact of landscape amenities on regional income based on empirical studies. Finally, the evidence suggesting an amenity impact on employment is limited. Only 4 out of 14 coefficient estimates were positive and significant, and one was even negative. The conclusion that can be drawn from the 14 analyzed articles is that population growth and net migration seems to be higher in high-amenity regions. However, the effect on employment change is weaker, while the impact on income change remains unclear.

How important are these amenity effects compared with other drivers of economic change? For this comparison, we also report effects of the two most common lagged economic opportunity variables – (wage-)income and unemployment – and a fiscal variable – tax burden – in Table 1[9]. In our study sample, high wages and incomes in the past did not induce a positive demographic and economic development. Only 2 out of the 19 estimated coefficients were positive, while 8 were even negative and significant. Also, low unemployment in the past did not explain future growth. However, 4 out of 8 estimates suggest that low local tax rates attracted people, while the effect on employment and income seems limited. Overall, these findings tend to support the equilibrium view (see section 2.1) since the evidence for disequilibrium forces is limited, while amenities seem to play a significant role and partly compensate lower wages (e.g. Nzaku and Bukenya, 2005). However, these findings are not uniform; some studies found that economic opportunity variables explain migration better than amenity variables. Greenwood and Hunt (1989, p. 2) argue that "if employment is growing most rapidly in amenity rich areas, and if employment change is not included as an explanatory variable in the migration equation, then the importance of job opportunities will in part be reflected in the coefficients associated with the amenities". In fact, only five studies in our sample used employment growth as an independent variable in their population equations. Four of them (Greenwood and Hunt, 1989[10]; Clark and Hunter, 1992; Lewis et al, 2002, 2003) conclude that high employment growth significantly promoted population change or

[9] We compare the frequency of significant effects of amenity and economic variables rather than reporting elasticities for two reasons: (1) in 6 studies no variable means are reported which makes it impossible to calculate elasticities at the sample mean. (2) Due to the substantial heterogeneity in dependent and independent variables a comparison of elasticities of amenities and economic variables is problematic (see section 4 and 4.1.).

[10] Greenwood and Hunt (1989) used workforce data, non-workers are excluded in their study. This may partly explain the high relative importance of job variables in their findings. Moreover, they only considered the direct effects of amenities and jobs on net-migration. However, they remark that amenity-rich places may attract migrants indirectly through job growth if amenities are capitalized into wages and lower wages attract firms.

net-migration. In addition, Porell (1982, p. 156) finds that "whereas in long-run equilibrium attractive QOL [quality of life] should be compensated by less attractive economic incentives, several SMSA's […] offered attractive economic incentives in addition to attractive QOL". Moreover, most of these studies did not control for housing prices[11], which might cause biases since amenities may capitalize not only in wages but also in rents (Roback, 1982, 1988).

Finally, it must be emphasized that the amenity effects reported in Table 1 are usually total effects. System of equations models estimated in their structural form allow in principle to partition this effect into a direct and an indirect effect (see Duffy-Deno, 1997b, 1998; Lewis et al., 2002, 2003; Hailu and Rosenberger, 2004). This approach yields a more distinct insight into the complex relationships between the endogenous variables. For example, Lewis et al. (2002) find that the conservation land share had a positive direct effect on net migration, whereas net migration positively influenced employment at the end of period. Therefore, the amenity variable had a direct effect on net migration as well as an indirect effect on employment.

4.3 Further findings

Some of the 14 studies focus on the commonly expressed concern that promoting natural preserves and wilderness areas might crowd out resource-sector employment, such as employment in the manufacturing of wood products, and harm the economy through lowering total employment, or replacing jobs in the resource-based sector with low-wage service jobs. Duffy-Deno (1998) finds that two types of land-use restrictions, the ownership of land by the United States Forest Service (USFS) and the Bureau of Land Management (BLM), had a negative impact on resource employment while there was no evidence of such an effect for federal wilderness. Duffy-Deno (1997a) and Lewis (2002) find no evidence for the crowding-out hypothesis. Moreover, Lewis (2003) could not reject the hypothesis that no wage effects result from preservation lands.

Greenwood and Hunt (1989) estimate annual labor force net-migration equations for the period 1958 to 1975. This approach is particularly interesting because it allows checking for possible changes in amenity demand. In the equilibrium view (see section 2.1 of this paper), migration occurs as an adjustment process to a new equilibrium when changes in demand for location-fixed amenities have taken place, for example through a generally rising level of real incomes (Graves and Linneman, 1979; Graves, 1980). In the absence of such

[11] Hailu and Rosenberger (2004) use median housing values in their model and found that low housing values are not positively associated with population growth.

changes in demand, migration would occur as a reaction to incentives through not fully compensated spatial differences in economic opportunities. Greenwood and Hunt (1989) find that the effect of national forests on net migration rates had risen in the 1970s compared to the 1960s. On the other hand, for most other (non-landscape) amenity variables in his model such an increment was absent, suggesting that disequilibrium forces had been at work.

Clark and Hunter (1992) analyze the relative importance of amenity, fiscal and economic opportunity variables in a life-cycle migration framework. They estimate a net-migration equation for each five-year age cohort of white males. The landscape amenity variable in their model (share of land in state parks, forests, water-use areas, trails, and other recreational areas) is found to have been a positive and significant determinant of net migration only for age cohorts from 40 upwards. Clark and Hunter receive similar results for all other natural amenities (climate and coastal variables): they find significant amenity effects for middle-aged and older males, while younger males tended to be attracted to labor-market features and migrated to city centers. Therefore, preferences were partly determined by life-cycle effects, families and retired people demanding landscape and other natural amenities rather than graduates who are just entering the labor market. The results of Clark and Hunter's research illustrate Greenwood's notion that personal characteristics are an important migration determinant alongside with economic, fiscal and amenity conditions in the sending and receiving locations (Greenwood, 1985). In a very recent article, Ferguson et al. (2007) estimate a comparable model using data from Canadian communities and a broadly defined amenity group containing landscape, weather and nonnatural amenities. They conclude that in rural areas economic factors – while declining in their influence with rising age – rather explain population growth than amenities do. However, in urban areas amenities and economic factors were of similar importance as migration determinants.

5 Empirical evidence from hedonic property value models

We analyze the role of amenities in reported hedonic regressions in two ways: In a first step (section 5.2), we provide an overview of the amenity effects reported for different groups of amenities. The second step consists of a meta-analysis regression in which we explore the determinants of significant amenity effects (section 5.3).

5.1 Study sample and definition of amenity groups

Based on the criteria in section 3, we found 25 relevant articles with 29 independent hedonic regressions (see Appendix B).[12] These articles were published between 1992 and 2005 in 15 academic journals mainly in the fields of environmental and resource, agricultural, and real-estate economics. Most of the study areas are located in the United States.[13] In the present study sample, there are often several model specifications reported for individual independent regressions. Moreover, the reported models may contain one or several amenity coefficients, and the definition of the amenity variables is never exactly the same in two studies. To usefully assess the reported evidence we thus distinguish the characteristics "regression", "specification", "amenity group", and "amenity coefficient". Hence, the reported amenity coefficients can be written b_{ijkl}, where i indicates the regression, j denotes the particular specification of the regression, k is the amenity group and l indicates the individual reported amenity coefficient.

We distinguish six landscape amenity groups: open space ("open space"), forest, trees and wooded areas ("forest"), wilderness, conservation areas and preserved land ("preserve"), wetlands ("wetland"), land in agricultural use ("agriculture") and landscape diversity, richness and fragmentation ("diverse"). These amenity variables appear as explanatory variables in the hedonic property value models in addition to other exogenous variables such as property attributes, neighborhood, and socio-economic variables. The amenity measures occur as proximity variables (e.g. distance to nearest forested area), proportion measures (e.g. percentage of land classified as open space within a given distance from the property) or as binary variables (e.g. vicinity of preserved land). Most studies in the sample deal with forest and open space amenities solely or with a combination of different landscape amenity types.

5.2 Overview of reported amenity effects

As mentioned above, many hedonic property value studies employ several alternative definitions of an amenity (e.g. percentage of open space within a radius of 200 and within a radius of 500 meters from the property) or estimate different specifications. For a first quantitative assessment of the reported amenity effects we pool the reported coefficients for each amenity group k and each specification j within regressions i, yielding a sample of n= 50 observations for b_{ik}. We define b_{ik} as a *significant* reported amenity effect if at least 50% of the pooled

[12] Thornes (2002) and Nicholls and Crompton (2005) estimated several models with independent sub-samples.
[13] Exemptions are Garrod and Willis (1992) and Cheshire and Sheppard (1995) who chose study areas in Great Britain. Luttik (2000) estimated a HP model with Data from the Netherlands and Tyrväinen (1997) as well as Tyrväinen and Miettinen (2000) worked with Finnish data.

amenity coefficients were positive and significant at the 5% level. In addition, we define b_{ik} as *robust* if all pooled amenity coefficients were positive and significant. Table 2 reports the number of observations that were significant and robust, respectively, for each amenity group. The underlying sample is presented in Appendix B.

For each of the amenities "open space", "forest", preserve", "wetland" and "diverse" the reported amenity effects were significant in about half of the observations. Of six observations for agricultural land-use ("agriculture") only one was significant. This indicates that agricultural land-use was rarely considered as an amenity. Negative or non-significant coefficients were estimated for agricultural land-uses such as cropland (Irwin, 2002), proximity to farms or agricultural land (Johnston et al., 2001; Smith et al., 2002), and percentage of land in agricultural use around property (Paterson and Boyle, 2002; Ready and Abdalla, 2005). The only agricultural land-use class with positive and significant reported impacts on property prices was pastureland (Bockstael, 1996). Other agricultural land-uses operated as negative externalities when controlling for other landscape amenities, which was done in all the hedonic regressions containing agricultural variables. This appears to be the result of emissions such as odors, water pollution and noise. The coefficients for forest measures were quite variable. The strength of wood amenity effects seemed to depend on the type of forest. Garrod and Willis (1992) find that the proportion of broadleaved woodland had a significantly positive impact on property prices, while conifers exhibited a negative and significant influence. Kim and Johnson (2002) also find no significantly positive effects for coniferous woodlands. Those findings may indicate that highly resource-extraction orientated (conifer) forests were less valued as an amenity than mixed broadleaved woodlands.

The frequency of robust amenity effects was similar among the different amenity groups, except for agricultural amenities where not a single robust (positive) effect was reported. This strengthens the insight that agricultural land-use exerts disamenity rather than amenity effects. The five other amenity variables were robust in much less than half of the hedonic regressions.

5.3 Meta-analysis regression

To further explore the pattern of reported amenity effects we use a meta-analysis regression to analyze how significant amenity effects in the hedonic regressions were influenced by the amenity type and additional study characteristics. The estimated model is given by:

$$S_i = \alpha_i + \phi X_i + e_i,$$

where S_i denotes whether regression i's reported amenity effects are positive and significantly different from zero. The response coefficients ϕ and the variables X_i are expected to affect the reported amenity effects. The e_i are i.i.d error terms with zero mean and constant variance σ^2_e. S_i is coded one if at least half of the reported amenity coefficients of regression i were significant at the $p < 0.05$ level and had a positive sign. The explanatory variables in the model are a set of dummy variables indicating the presence/absence of the different amenity groups in the reported regressions and additional study characteristics may determine likelihood of observed amenity effects. The amenity dummies are coded based on the amenity groups in section 5.2. The variables OPENSPACE, FOREST, PRESERVE, WETLAND, AGRI and DIVERSE take the value one if the respective amenity variable was the *only* amenity in the hedonic regressions. To account for models with several amenity variables of different categories, we created an additional variable MIXED. Using these definitions, we found significant amenity variables in slightly less than half of the observations (Table 3).

In addition to effects of the landscape amenity variables themselves, we were also interested in additional study characteristics that may potentially affect the amenity coefficients. The hedonic studies examined do not only differ in the choice of amenity measures. The geographic region is one further study-specific feature. We distinguished between local and regional as well as rural and non-rural study areas, as captured by the variables RURAL and LOCAL defined in Table 3. Only two studies used purely rural samples. Furthermore, most studies used local data. This may be due in part to geographical limitations of property sales data, which often do not cover large contiguous regions.

Furthermore, 13 of 29 hedonic regressions in our sample considered other natural amenities in addition to the landscape amenity variables (NONLAND). In most cases, such amenities related to watercourses. Finally, an important econometric feature is the presence or absence of controls for spatial autocorrelation (AUTOCOR) such as spatial error models and Moran's I statistic. Seven studies controlled for spatial autocorrelation, all of them published between 2000 and 2005. This appears to be a result of the rising awareness of spatial effects and the progress in spatial econometrics in recent years.

The coefficient estimates of the Probit model to explain the presence / absence of significant amenity effects are reported in Table 4. We included the common amenity dummies OPENSPACE and FOREST as explanatory variables, together with the data and method variables RURAL, LOCAL, NONLAND and AUTOCOR. The correlation matrix suggested that this specification shows no multicollinearity problems.

The coefficient on LOCAL was negative and significant while all other coefficients were insignificant. Therefore, larger study areas which contain several counties or whole states led to positive and significant landscape amenity effects more frequently than spatially limited single-town or single-county datasets do. This may be the result of the tendency towards more variation in the endowment of amenities with increasing study area size. The non-significance of the amenity variables OPENSPACE and FOREST is consistent with Table 2 and confirms that the frequency of reported significant amenity effects does not differ significantly between the different amenity groups.

6 Conclusion

Empirical evidence on effects of amenities on property prices, population, employment, and income is useful to understand the increasingly important links between landscape management and economic change. While several studies have surveyed the role of environmental regulations on economic development (e.g. Jeppesen et al., 2002) the present study is the first to review the available evidence on the role of land-use related amenities in local economic change. Overall, our survey confirms that amenities enter the utility function of individuals and are a substantial determinant of migration flows. Nevertheless, economic opportunity and fiscal factors are also crucial and therefore spatial differences in rents and wages only partly reflect compensations for differentials in amenity endowment.

The available regional economic and migration studies suggest that amenity-rich regions tended to grow faster in terms of population than other areas. In the empirical studies we analyzed, significant and positive amenity effects were comparable in frequency with those of a low tax burden. Evidence from several studies suggests that the conservation of natural amenities for recreational uses did not harm the local economy through crowding-out resource-based employment. However, the overall impact on economic development remains unclear as there is very little evidence of a persistent link, either direct or indirect, between amenities, employment and income. The notion of landscape amenities as a development tool therefore still lacks unambiguous empirical support. We identify two specific research needs: there is a need for regional economic simultaneous equations studies with a broader range of specific amenity measures. Newly available land-cover datasets and spatial analysis tools have the potential to overcome important data limitations of many earlier studies. Furthermore, little attention has been paid to life-cycle effects and the personal characteristics of migrants attracted by amenities. This focus is crucial in order to understand the consequences of

amenity-induced migration for regional economic development (Greenwood, 1985). Key questions are: (1) what kind of individuals are attracted by what kind of amenities? and (2) what are the consequences of the socioeconomic characteristics of these individuals with regard to the regional economic development?

The evidence from hedonic pricing studies contributes to a better microeconomic foundation of models of amenity-driven development. Our meta-analysis suggests that landscape amenities such as open space, woodlands and preservation or wilderness areas adjacent to or near properties all tend to increase property prices. By contrast, some agricultural land-use variables, namely some types of cropland and proximity to farms, are valued as disamenities. These results show that landscape amenities are partly capitalized in rents. However, utility gains through higher amenity endowments may also partly be reflected in wages (Roback, 1982, 1988), which calls for multi-market hedonic models. An improved comprehension of this capitalization process is also needed in order to better understand the relationship between amenities and employment, since the latter depends on wage levels.

The potential role of landscape amenities in regional development is relevant for policy. It is a striking insight from our survey that evidence for European regions is virtually absent in the compiled literature. In Europe, the EU Council's strategic guidelines for rural development policy under the European Agricultural Fund for Rural Development explicitly aims "to ensure the consistency of rural development with other Community policies, in particular in the field of cohesion and environment" (Council, 2006). Considering the sizable budget involved[14], identifying consistent policies is clearly an important objective to which empirical research can contribute. The recent advances in geographic information technology and data availability open up new opportunities for research that leads to an improved understanding of the role of attractive landscape in the development process.

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[14] The EU support for rural development for the period of 2007 to 2013 amounts to 88 billion Euro (http://ec.europa.eu/budget/documents/multiannual_framework_en.htm, accessed 13.4.2007). Of the 126-billion-Euro EU budget for 2007, 34 percent are allocated to the management of natural resources (http://ec.europa.eu/budget/index_en.htm, accessed 13.4.2007)

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Table 1. Reported amenity, fiscal, and economic opportunity impacts on population, employment, and income variables: frequencies[a]

	Amenity effects			Effects of high wages / income			Effects of low unemployment			Effects of low taxes		
	No. obs.[b]	Sig.[c]	Neg. sig.[d]	No. obs.	Sig.	Neg. sig.	No. obs.	Sig.	Neg. sig.	No. obs.	Sig.	Neg. sig.
Population	8	3	2	2	1	1	3	0	2	6	3	0
Migration	7	4	0	7	1	2	5	0	0	2	1	1
Total population and migration variables	15 (13)	7	2	9 (7)	2	3	8 (6)	0	2	8 (7)	4	1
Employment	6	3	0	3	0	1	5	2	1	3	1	0
Employment in the resource-based sector	3	0	1	3	0	1	3	0	0	3	1	0
Employment in other specified sectors	5	1	0	3	0	2	3	0	3	4	0	0
Total employment variables	14 (11)	4	1	9 (5)	0	4	11 (7)	2	4	10 (7)	2	0
Income (per capita)	3	0	0	1	0	1	2	2	0	3	1	0
Specified income classes	4	3	0	0	0	0	1	0	0	0	0	0
Total income variables	7 (5)	3	0	1 (1)	0	1	3 (3)	2	0	3 (3)	1	0
SUM	36	14	3	19	2	8	22	4	6	21	7	1
in %	100.0	38.9	8.3	100.0	10.5	42.1	100.0	18.2	27.3	100.0	33.3	4.8

[a] The underlying sample is given in Appendix A.
[b] Number of estimates containing the respective dependent and independent variable. In brackets: number of studies containing the respective estimates.
[c] Number of estimates with coefficients that are positive and significant on the 5% level. Procedure with multiple coefficients (e.g. several amenity variables or several model specifications): At least 50% of the coefficients must be positive and significant.
[d] Number of estimates that are negative and significant on the 5% level. Procedure with multiple coefficients (e.g. several amenity variables): At least 50% of the coefficients must be negative and significant.

Table 2. Frequency of significant and robust reported amenity effects in the HP studies[a]

	Landscape amenity variables: Frequencies						
	Open space[b]	Forest[b]	Preserve[b]	Wetland[b]	Agriculture[b]	Diverse[b]	Sum
Sample size	16	14	7	3	6	4	50
Effect significant[b]	7	7	5	1	1	2	23
Effect robust[b]	2	2	2	1	0	2	9

[a] The underlying sample is given in Appendix B.
[b] See the Section 5.1 for definitions.

Table 3. Definitions and means of variables used in meta-analysis

Variable	Definition	Frequency of "1"	Percent
Dependent Variable			
S[a]	5% significance of landscape amenity variable in model[b]	14	48.3
Amenity Variables			
OPENSPACE	Open space as sole landscape amenity variable in model[c]	7	24.1
FOREST	Forest as sole landscape amenity variable in model[c]	8	27.6
PRESERVE	Preserved land / wilderness area / conservation area as sole landscape amenity variable in model[c]	1	3.4
WETLAND	Wetland as sole landscape amenity variable in model[c]	1	3.4
AGRI	Agricultural landscape as sole landscape amenity variable in model[c]	0	0.0
DIVERSE	Measure for landscape diversity, richness or fragmentation as sole landscape amenity variable in model[c]	0	0.0
MIXED	Several landscape amenity variables in model[c]	12	41.4
Other Variables			
RURAL	Rural study area, no urban or suburban sub-areas included[c]	2	6.9
LOCAL	Local model: maximum 1 county as object of investigation[c]	21	72.4
NONLAND	Environmental variables other than landscape amenity variables in model[c]	13	44.8
AUTOCOR	Control for spatial autocorrelation[c]	7	24.1

[a] Procedure with multiple variables / model specifications: 1 if at least 50% of the variables are positive and significant, 0 otherwise.
[b] 1 if positive and significant, 0 otherwise.
[c] 1=yes, 0=no.

Table 4. Probit coefficients for variables explaining presence/absence of significant amenity coefficients (*S*)

	Coefficient	Standard error
Constant	1.355	0.891
OPENSPACE	0.084	0.837
FOREST	0.525	0.820
RURAL	-0.024	1.256
LOCAL	-1.789*	0.727
NONLAND	-0.528	0.740
AUTOCOR	0.184	0.700
N	29	
Log*L* unrestricted	-15.15	
Log*L* restricted	-20.08	
χ^2	9.86	
Significance level	0.131	

* Significant at $p<0.05$.

Appendix A: survey sample migration and regional economic studies[a]

Author(s)	Journal	Dependent variable[b]	L	Model[c]	Amen[d]	Tax[e]	Wage[e]	Unempl[e]	Acr	Estimation[f]
Booth, 1999	GC	Pop	1	RE	1	--	--	--	0	OLS
Booth, 1999	GC	Empl	1	RE	1	--	--	--	0	OLS
Booth, 1999	GC	Inc	1	RE	0	--	--	--	0	OLS
Booth, 1999	GC	Inc (wage)	1	RE	1	--	--	--	0	OLS
Booth, 1999	GC	Inc (dividend)	1	RE	1	--	--	--	0	OLS
Booth, 1999	GC	Inc (transfer)	1	RE	1	--	--	--	0	OLS
Clark and Hunter, 1992	JRS	NetMig (age>40)	1	MIG / LC	1	1	0 [-]	0	0	OLS
Clark and Hunter, 1992	JRS	NetMig (age≤40)	1	MIG / LC	0	0 [-]	0 [-]	0	0	OLS
Deller et al., 2001	AJAE	Pop	0	RE	1	1	0 [-]	0 [-]	0	OLS
Deller et al., 2001	AJAE	Empl	0	RE	1	0	0 [-]	1	0	OLS
Deller et al., 2001	AJAE	Inc (per capita)	0	RE	0	1	0 [-]	1	0	OLS
Duffy-Deno, 1997a	GC	Pop	0	RE / SEQ	0	1	--	--	0	2SLS
Duffy-Deno, 1997a	GC	Empl (non-resource)	0	RE / SEQ	0	0	0 [-]	0 [-]	0	2SLS
Duffy-Deno, 1997a	GC	Empl (resource)	0	RE / SEQ	0	0	0	0	0	2SLS
Duffy-Deno, 1997b	JLR	Pop	1	RE / SEQ	1	0	--	--	0	2SLS
Duffy-Deno, 1997b	JLR	Empl (non-resource)	1	RE / SEQ	1	0	0 [-]	0 [-]	0	2SLS
Duffy-Deno, 1997b	JLR	Empl (resource)	1	RE / SEQ	0	0	0 [-]	0	0	2SLS
Duffy-Deno, 1998	JRS	Pop	1	RE / SEQ	0	1	--	--	1	2SLS
Duffy-Deno, 1998	JRS	Empl (non-resource)	1	RE / SEQ	0	0	0	0 [-]	1	2SLS
Duffy-Deno, 1998	JRS	Empl (resource)	1	RE / SEQ	0 [-]	1	0	0	1	2SLS
Duffy-Deno, 1998	JRS	Empl	1	RE / SEQ	0	0	0	0 [-]	1	2SLS
Gottlieb, 1995	US	Empl (high-tech)	1	RE / FL	0	--	--	--	1	Tobit / MLE, logit / min chi-square
Greenwood and Hunt, 1989	JUE	NetMig	1	RE / SEQ	0	--	0	0	0	OLS, 2SLS, 3SLS
Hailu and Rosenberger, 2004	ARER	Pop	0	RE / SEQ	0 [-]	0	--	0 [-]	0	2SLS

(continued on next page)

(Appendix A, continued)

Author(s)	Journal	Dependent variable[b]	L	Model[c]	Amen[d]	Tax[e]	Wage[e]	Unempl[e]	Acr	Estimation[f]
Hailu and Rosenberger, 2004	ARER	Empl	0	RE / SEQ	1	0	--	--	0	2SLS
Kim et al., 2005	GC	Pop	0	RE	0	0	--	--	1	SEM, MLE
Kim et al., 2005	GC	Empl (retail and service)	0	RE	0	0	--	--	1	SEM, MLE
Kim et al., 2005	GC	Inc (per capita)	0	RE	0	0	--	--	1	SEM, MLE
Lewis et al., 2002	LE	Empl	0	RE / SEQ	0	--	--	0	1	3SLS
Lewis et al., 2002	LE	NetMig	1	RE / SEQ	1	--	0	--	1	3SLS
Lewis et al., 2003	GC	Empl	0	RE / SEQ	0	--	--	0	1	3SLS
Lewis et al., 2003	GC	NetMig	1	RE / SEQ	1	--	0	--	1	3SLS
Lewis et al., 2003	GC	Inc (wage per capita)	0	RE / SEQ	0	--	--	0	1	3SLS
Nzaku and Bukenya, 2005	RURDS	Pop	0	RE / SEQ	0 [-]	--	1	0	1	MLE
Nzaku and Bukenya, 2005	RURDS	Empl	0	RE / SEQ	--	1	0	1	1	MLE
Nzaku and Bukenya, 2005	RURDS	Inc (per capita)	0	RE / SEQ	--	0	--	1	1	MLE
Porell, 1982	JRS	InMig	1	MIG / GR	1	--	1	0	0	OLS, fixed effects
Porell, 1982	JRS	OutMig	1	MIG / GR	0	--	0	0	0	OLS, fixed effects

[a] Column headings: L=levels specification (1=levels specification, 0=flow specification), Model=model type, Amen=amenity, Tax=effect of low local tax rates, Wage=effect of high average wage / income, Unempl=effect of low local unemployment, Acr=test for spatial autocorrelation (1=yes, 0=no).
[b] Pop=population, Empl=employment, Inc=income, NetMig=net migration, InMig=in-migration, OutMig=out-migration.
[c] RE=regional economic / urban economic, MIG=migration, LC=life-cycle, SEQ=system of equations, FL=firm location decision, GR=gravity.
[d] 1=at least 50% of amenity coefficients in model are positive and significant on the 5% level, 0=non-significant, 0 [-]=negative and significant.
[e] 1=positive and significant on the 5% level, 0=non-significant, 0 [-]=negative and significant.
[f] OLS=ordinary least squares, 2SLS=two stage least squares, 3SLS=three stage least squares, MLE=maximum likelihood estimator.

Appendix B: survey sample HP estimates

Author(s)	Journal	Amenity[a]	Sig[b]	Robust[b]	RURAL[c]	LOCAL[c]	NONLAND[c]	AUTOCOR[c]
Acharya and Bennet, 2001	JREFE	OS	1	1	0	1	1	1
Acharya and Bennet, 2001	JREFE	DIV	0	0	0	1	1	1
Bastian et al., 2002	EE	DIV	1	1	1	0	1	1
Bastian et al., 2002	EE	PR	0	0	1	0	1	1
Bockstael, 1996	AJAE	PR	1	1	0	0	1	0
Bockstael, 1996	AJAE	FOR	0	0	0	0	1	0
Bockstael, 1996	AJAE	AG	1	0	0	0	1	0
Cheshire and Sheppard, 1995	EC	OS	1	0	0	1	0	0
Garrod and Willis, 1992	ERE	FOR	1	0	0	0	0	0
Geoghegan et al., 1997	EE	OS	0	0	0	0	1	0
Geoghegan et al., 1997	EE	DIV	0	0	0	0	1	0
Geoghegan, 2002	LUP	OS	1	0	0	1	0	0
Irwin and Bockstael, 2001	AJAE	OS	1	0	0	0	0	1
Irwin and Bockstael, 2001	AJAE	PR	1	1	0	0	0	1
Irwin, 2002	LE	AG	0	0	0	0	0	1
Irwin, 2002	LE	FOR	0	0	0	0	0	1
Irwin, 2002	LE	PR	1	0	0	0	0	1
Irwin, 2002	LE	OS	1	0	0	0	0	1
Johnston et al., 2001	GC	AG	0	0	1	1	1	0
Johnston et al., 2001	GC	OS	0	0	1	1	1	0
Johnston et al., 2001	GC	WET	0	0	1	1	1	0
Kim and Johnson, 2002	SNR	FOR	0	0	0	1	0	0
Legget and Bockstael, 2000	JEEM	OS	0	0	0	1	1	1
Luttik, 2000	LUP	OS	0	0	0	0	1	0
Luttik, 2000	LUP	FOR	1	1	0	0	1	0
Luttik, 2000	LUP	DIV	1	1	0	0	1	0

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(Appendix B, continued)

Author(s)	Journal	Amenity[a]	Sig[b]	Robust[b]	RURAL[c]	LOCAL[c]	NONLAND[c]	AUTOCOR[c]
Lutzenhiser and Netusil, 2001	CEP	PR	1	0	0	1	1	0
Mahan et al., 2000	LE	WET	1	1	0	1	1	0
Mansfield et al., 2005	JFE	FOR	1	0	0	0	0	0
Netusil, 2005	LE	OS	1	1	0	1	1	0
Netusil, 2005	LE	FOR	1	0	0	1	1	0
Netusil, 2005	LE	WET	0	0	0	1	1	0
Netusil, 2005	LE	PR	0	0	0	1	1	0
Nicholls and Crompton, 2005	JLR	OS	0	0	0	1	0	0
Nicholls and Crompton, 2005	JLR	OS	0	0	0	1	0	0
Nicholls and Crompton, 2005	JLR	OS	0	0	0	1	0	0
Paterson and Boyle, 2002	LE	AG	0	0	0	1	1	1
Paterson and Boyle, 2002	LE	FOR	0	0	0	1	1	1
Ready and Abdalla, 2005	AJAE	OS	1	0	0	1	1	0
Ready and Abdalla, 2005	AJAE	AG	0	0	0	1	1	0
Schultz and King, 2001	JREFE	PR	1	0	0	1	0	0
Schultz and King, 2001	JREFE	OS	0	0	0	1	0	0
Smith et al., 2002	REE	OS	0	0	0	1	0	0
Smith et al., 2002	REE	FOR	0	0	0	1	0	0
Smith et al., 2002	REE	AG	0	0	0	1	0	0
Thornes, 2002	LE	FOR	1	0	0	1	0	0
Thornes, 2002	LE	FOR	1	0	0	1	0	0
Thornes, 2002	LE	FOR	0	0	0	1	0	0
Tyrväinen, 1997	LUP	FOR	0	0	0	1	1	0
Tyrväinen and Miettinen, 2000	JEEM	FOR	1	1	0	1	0	1

[a] Amenity groups: OS=open space, FOR=forest, PR=preserve, WET=wetland, AG=agriculture, DIV=diverse. See section 5.1 for the definitions of these amenity groups.

[b] Sig=effect significant, Robust=effect robust. For definitions see Section 5.2.
[c] For definitions see Section 5.3.

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